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Assessment of relative toxicity of insecticides to the green plant bug, *Lygus lucorum* Meyer-Dür (Hemiptera: Miridae), by two different bioassay methods

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Abstract: The economic importance of the green plant bug, *Lygus lucorum* Meyer-Dür, has become prominent in area where transgenic Bt cotton are widely planted in China. Controlling of green plant bugs relies mainly on insecticides, and chemical control is one of the important strategies used in IPM. This study was designed to assess acute contact toxicities of conventional and novel insecticides to green plant bugs by two different bioassay methods including glass-vial and topical application. Thirty insecticides, including organochlorines, organophosphates, pyrethroids, carbamates, nereistoxins, neonicotinoids, phenylpyrazoles, antibiotics, insect growth regulators (IGRs), and botanical insecticides were selected to investigate their toxicities against adult green plant bugs. Median lethal concentrations (LC_{50}) of some insecticides were first determined by the two methods. The results showed that in laboratory bioassays, general insecticides including organochlorines, organophosphates, carbamates and pyrethroids were highly toxic to adult green plant bugs. Five (malathion, chlorpyrifos, bifenthrin, methomyl and endosulfan) of eight most toxic insecticides on the bugs among all the test chemicals were general insecticides. Novel insecticides phenylpyrazole showed the highest acute contact toxicity, of which fipronil had the highest toxicity to green plant bugs. The LC_{50} values of fipronil by two bioassay methods were 0.13 and 0.15 $mg \cdot L^{-1}$, respectively. IGRs, antibiotics and botanical insecticides, however, had no obvious acute contact toxicity to adult green plant bugs.

Key words: *Lygus lucorum*; technical insecticides; relative toxicity; contact toxicity; glass-vial; topical application

1 INTRODUCTION

Recently, as a result of the mass cultivation of transgenic Bt cotton in northern China, the green plant bug, *Lygus lucorum* Meyer-Dür, has emerged as an economically important pest of this crop. Since the mid-1990s, Bt cotton began to be commercially planted and expanded rapidly to 1.067 million ha. in 2000 in this region (Qu *et al.*, 2001). The widespread cultivation of Bt cotton has provided effective control of cotton bollworm *Helicoverpa armigera* (Hübner) which is a key pest of cotton while greatly reducing insecticide use in this crop. A major reduction of broad-spectrum insecticide used in Bt cotton has allowed plant bugs to resurge and become destructive pests of this crop (Guo, 1997; Wu *et al.*, 2002; Lu *et al.*, 2007). Mirid population outbreaks were greatly synchronized with the cotton flowering and squaring stages, which are the most susceptible to the damage of plant bugs (Cao and Wan, 1983). Feeding by plant bugs in cotton results in abortion of terminals, shedding of squares and bolls, malformation of seeds and lint, and therefore may greatly delay maturity and reduce cotton yields (Zhu and Meng, 1958; Ting, 1965). The damage of green plant bugs to cotton could increase further with the enlargement of the Bt cotton area if no additional control measures are adopted (Lu *et al.*, 2007).

Chemical control remains a major strategy in the Integrated Pest Management (IPM) system of plant bugs because it is efficient, easy to operate, cost-effective, and reliable against insect pests (Zhao, 2000). Broad-spectrum insecticide sprays are thought to be effective measures of controlling plant bugs, because few alternative control measures are available (Hardee and Bryan, 1997; Wu, 2007). But misuse of chemical insecticides might account for the outbreaks

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of the pest because extensive and intensive use of insecticides applied heavy selection pressure on target pests and accelerated resistance development. Therefore, chemical insecticides need to be correctly and selectively used to ensure sustainable crop protection and environmental stability. The study in search of efficient insecticides controlling plant bugs may promote the implementation of IPM in Bt cotton. The reasonable use of insecticides may also reduce the risk of pest resistance developing, and help to realize sustainable development of agriculture.

Currently, many low-toxicity organophosphates, pyrethroids, and other novel insecticides are being investigated as potential alternatives to replace highly toxic organophosphate insecticides. In this study, 30 insecticides with different modes of action were selected to investigate their acute toxicities to adult green plant bugs by two different bioassay methods. The information from this study is needed for analyzing and directing the chemical control of green plant bugs effectively.

2 MATERIALS AND METHODS

2.1 Insects

Green plant bugs (*Lygus lucorum* Meyer-Dür) were collected from weeds *Humulus scandens* (Lour.) near by cotton field using sweep nets in Sep. 2007 in Xiajin, Shandong province. During this period, the cotton was mature and unattractive, so the bugs migrated from cotton to wild hosts which were flowering. Bugs were aspirated from the sweep nets following collection in fields and placed into plastic insect boxes (23 cm length × 15 cm width × 9 cm high) with green bean pods *Phaseolus vulgaris* L. Beans were washed in detergent and soaked in a 3% sodium hypochlorite solution as described in Snodgrass (1996) to remove or oxidize any insecticide residue on them.

The laboratory colony of green plant bugs for determining the toxicity of insecticides was established in our laboratory. The bugs were held in plastic insect boxes with 50 – 60 adults per box provisioned with green bean pods and honey solution under laboratory conditions of 25 ± 1℃, 40% – 65% RH, 14L: 10D. During the mating period, the boxes containing adults were checked daily for oviposition. If eggs were found, the green bean pods on which eggs were oviposited were kept under ventilative environment in the laboratory for 2 – 3 d to decrease water content for avoiding the rot of beans and increasing egg hatching rate, and then removed and transferred to new containers. After eggs hatched and nymphs dispersed from eggs (*i. e.*, 1 d after hatch), individuals of the generation were placed individually into separate plastic insect boxes with shredded paper that was placed snugly in position. The container lid had the inner portion cut out and a piece of gauze placed over the top to seal the container. Nymphs were fed with washed green bean pods placed inside the containers till the desired developmental stages for test.

The 5 d old unsexed laboratory reared adult green plant bugs were used for toxicity test by two bioassay methods.

2.2 Insecticides

A total of 30 insecticides were tested. All insecticides used in these tests were technical grade insecticides and fell into ten insecticidal classes. Organochlorine: 95% endosulfan (Israel Makhteshim-Agan Industries Ltd.). Organophosphates: 91% phoxim (Jiangsu Baoling Chemical Co., Ltd.); 90% profenofos (Jiangsu Baoling Chemical Co., Ltd.); 95% acephate; Sinon Chemical (Shanghai) Co., Ltd]; 95% malathion (Sinochem Ningbo Chemical Co., Ltd.); 97% chlorpyrifos (America Dow AgroSciences LLC.); 91% methidathion (Swiss Syngenta Crop Protection Inc.); 93% fenitrothion (Sinochem Ningbo Chemical Co., Ltd.); 94.5% ethoprop (Shandong Pesticide Industry United Co., Ltd.); 85% triazophos (Anhui Shenli Pesticide & Chemistry Co., Ltd.). Pyrethroids: 95% lambda-cyhalothrin (Jiangsu Yangnong Chemical Co., Ltd.); 95% fenpropathrin (Dalian Raiser Pesticides Co., Ltd.); 99% beta-cypermethrin (Shandong Dachen Pesticide Co., Ltd.); 97% bifenthrin (Jiangsu Yangnong Chemical Co., Ltd.). Carbamates: 98% isoprocarb (Shandong Huayang Technology Co., Ltd.); 98% methomyl (Jiangsu Changlong Chemicals Co., Ltd.). Nereistoxins: 95% Cartap (Japan Sumitomo Chemical Co., Ltd.); 95% monosultap (Chongqing Pesticide & Chemical Industry Co., Ltd.). Neonicotinoids: 98% thiamethoxam (Swiss Syngenta Crop Protection Inc.); 95% acetaniprid (Shandong Pesticide Industry United Co., Ltd.); 95% imidacloprid (Zhejiang Hisun Chemical Co., Lid.). Phenylpyrazoles: 96% butene-fipronil (Dalian Raiser Pesticides Co., Ltd.); 95% fipronil (Hangzhou Bayer Crop Science Ltd.); 94.5% chlorfenapyr (Germany BASF Aktiengesellschaft). Antibiotics: 94% abamectin (Zhejiang Hisun Chemical Co., Lid.); 95% emamectin benzoate (Swiss Syngenta Crop Protection Inc.); 90% spinosad (America Dow AgroSciences LLC.). Insect growth regulators (IGRs): 97% hexaflumuron (America Dow AgroSciences LLC.). Botanicals: 40% azadirachtin (Yunnan Zhongke Bio-Industry Co., Ltd.); 95% marine (Dezhou Hengdong Chemical Co., Ltd.).

2.3 Bioassay methods for toxicity determination

Glass-vial bioassay (Snodgrass, 1996) was used to determine the toxicity of insecticides to adult green plant bugs. Adults were placed into 20 mL glass scintillation vials (28 mm diameter and 61 mm height) that had been treated with the test insecticides. Each insecticide was applied by pipetting 0.5 mL of the insecticide dissolved in acetone (≥99.7%, analytical reagent) into each vial. Serial dilutions were used to obtain desired concentrations. Each vial was slowly rolled for several minutes until an even layer of insecticide dried on its inner surface. Vials in control treatments received only 0.5 mL of acetone. Vials were used on the same day they were coated with insecticides. A small piece of washing and sterilized green bean pod (cut transversely) about 3 mm thick was added to each vial as food for the adults, 2 adults were transferred into one vial from the plastic insect box and the vial was then sealed by one layer gauze. Vials were held during the test in an upright position under laboratory conditions of 25 ± 1℃, 40% -65% RH, and 14L: 10D.

Toxicity test of insecticides against adults was also applied with topical application method. Acetone was used as the solvent and control. The thoracic notum of bugs, which were diethyl ether anaesthetized, was dripped with 0.5 μL insecticide by microapplicator (Robbins Scientific® Repeating Dispenser, 25 μL single syringe), and 10 adults were included in each group. The treated bugs were transferred to the glass insect tube (two insects per tube), and a small piece of green been pod about 3 mm thick was added. The tubes were sealed with one layer gauze, held upright at condition of 25 ± 1℃, 40% -65% RH, 14L: 10D.

All bioassays had 3 replications of 6 - 9 different insecticide concentrations, and each replication of each concentration included 5 vials with 2 adults. Mortality was determined after 24 h, and adults were considered dead if they were unable to stand normally or walk, or there was no movement when they were prodded.

2.4 Statistical analysis

Data were corrected for control mortality using Abbott's formula (Abbott, 1925) before analysis, and the data were analyzed with SAS/STAT® version 6.12 (SAS Institute Inc., 1997). Statistical differences between LCs were determined using the presence or absence of overlap in the 95% confidence limits.

3 RESULTS

3.1 Median lethal concentration (LC_{50}) by glass-vial

Data of contact toxicity of 30 insecticides to adult green plant bugs by glass-vial bioassay are summarized in Table 1. Mortality in all control groups was consistently below 5%. Organophosphate, pyrethroids and phenylpyrazole insecticides were highly toxic to adults, but hexaflumuron (IGRs), antibiotics and botanical insecticides were lower. Eight most toxic chemicals for the bugs among all testing insecticides were ranked as follows: fipronil and butene-fipronil > bifenthrin and methomyl > malathion, chlorpyrifos, fenitrothion and endosulfan (LC_{50}'s with overlapping confidence intervals were classified as the same rank). Among all the 30 insecticides, the contact toxicity of fipronil was the highest, and its LC_{50} value was only 0.13 mg · L^{-1}. Seven insecticides, *i. e.*, spinosad, abamectin, hexaflumuron, chlorfenapyr, monosultap, azadirachtin and matrine, showed the lowest toxicity to the bugs. The LC_{50} values for the insecticides were more than 1 000 mg · L^{-1}.

3.2 Median lethal concentration (LC_{50}) by topical application

The LC_{50} values for insecticides tested against green plant bugs by topical application at 24 h were summarized in Table 2. Eight most toxic chemicals for the bugs among all testing insecticides were ranked as follows: fipronil and butene-fipronil > chlorpyrifos > bifenthrin and endosulfan > methomyl > fenpropathrin and malathion. The result obtained by topical application was not significantly different as compared with glass-vial bioassay. Among all the 30 insecticides, the contact toxicity of fipronil was also the highest, and its LC_{50} value was 0.15 mg · L^{-1}. Triazophos, hexaflumuron, monosultap, azadirachtin and matrine had the lowest toxicity, the LC_{50} values were more than 1 000 mg · L^{-1}.

4 DISCUSSION

During recent years the relative importance of green plant bugs *L. lucorum* has increased significantly, especially in northern China. Lu *et al.* (2007) suggested that *L. lucorum* should be treated as one of the main targets for developing pestiferous mirid management strategies in Bt cotton fields in China. Therefore, green plant bug population outbreaks have resulted in a need for more insecticide treatments specifically targeted against mirids. Chemical control is thought to be an effective measure in IPM of green plant bugs in Bt cotton. The present studies were carried out to evaluate the toxicity of a wide range of insecticides including conventional and novel insecticides against green plant bugs by two bioassay methods. The results demonstrated that different insecticides possessed significantly different toxicities to adults, which in turn might provide more choices for chemical control.

In laboratory bioassays, a majority of conventional insecticides including organochlorines, organophosphates, carbamates and pyrethroids maintained high toxicity to adult green plant bugs. Adults were relatively sensitive to chlorpyrifos, malathion, bifenthrin and methomyl, and LC_{50} values for these 4 compounds were lower among insecticides tested by two bioassay methods (Table 1 and Table 2).

Table 1 Toxicity (LC_{50}) for contact toxicity of 30 insecticides to unsexed laboratory reared green plant bugs by glass-vial at 24 h

Insecticides	Slope ± *SE*	LC_{50} (mg · L^{-1})	95% Confidence limit	Relative toxicity index
Organochlorines				
Endosulfan	2.81 ±0.63	5.53	3.36 – 13.99	0.006
Organophosphates				
Malathion	2.88 ±0.52	7.78	5.11 – 14.81	0.008
Chlorpyrifos	2.58 ±0.38	9.66	6.99 – 14.87	0.010
Fenitrothion	1.87 ±0.20	12.65	10.78 – 14.85	0.013
Methidathion	1.64 ±0.09	28.15	25.15 – 31.50	0.029
Profenofos	1.83 ±0.01	29.04	28.70 – 29.39	0.030
Phoxim	0.98 ±0.04	30.85	28.04 – 33.93	0.032
Ethoprop	3.04 ±0.23	40.03	35.66 – 44.95	0.042
Acephate	1.43 ±0.07	57.65	51.90 – 64.03	0.060
Triazophos	1.15 ±0.02	963.14	935.93 – 991.15	1.000
Pyrethroids				
Bifenthrin	2.73 ±0.53	1.53	1.21 – 2.06	0.002
Beta-cypermethrin	1.83 ±0.23	35.98	26.25 – 49.33	0.037
Fenpropathrin	1.14 ±0.04	61.43	54.52 – 69.23	0.064
Lambda-cyhalothrin	2.31 ±0.05	143.24	138.11 – 148.57	0.149
Carbamates				
Methomyl	2.66 ±1.47	2.22	2.02 – 2.48	0.002
Isoprocarb	2.06 ±0.09	60.62	56.76 – 64.73	0.063
Nereistoxins				
Cartap	2.69 ±0.08	41.00	39.25 – 42.82	0.043
Monosultap	3.00 ±0.11	>1 000.00	–	>1.000
Neonicotinoids				
Thiamethoxam	2.21 ±0.10	64.74	60.41 – 69.38	0.067
Imidacloprid	1.29 ±0.02	158.00	155.25 – 160.81	0.164
Actaniprid	2.40 ±0.18	356.08	314.82 – 402.76	0.370
Phenylpyrazoles				
Fipronil	2.35 ±0.99	0.13	0.10 – 0.17	<0.001
Butene-fipronil	2.83 ±0.35	0.16	0.13 – 0.19	<0.001
Chlorfenapyr	3.24 ±0.01	>1 000.00	–	>1.000
Antibiotics				
Emamectin	1.01 ±0.04	221.33	202.97 – 241.34	0.230
Spinosad	1.48 ±0.02	>1 000.00	–	>1.000
Abamectin	2.36 ±0.14	>1 000.00	–	>1.000
IGRs				
Hexaflumuron	1.42 ±0.07	>1 000.00	–	>1.000
Botanicals				
Azadirachtin	2.01 ±0.10	>1 000.00	–	>1.000
Matrine	2.02 ±0.10	>1 000.00	–	>1.000

>1 000: When the concentration was 1 000 mg · L^{-1}, the mortality of bugs was less than 50%.

Table 2 Toxicity (LC_{50}) for contact toxicity of 30 insecticides to unsexed laboratory reared green plant bugs by topical application at 24 h

Insecticides	Slope ± *SE*	LC_{50} ($mg \cdot L^{-1}$)	95% Confidence limit	Relative toxicity index
Organochlorines				
Endosulfan	1.74 ±0.13	4.02	3.50 – 4.61	0.004
Organophosphates				
Chlorpyrifos	1.79 ±0.23	2.45	2.32 – 2.58	0.003
Malathion	1.48 ±0.17	40.73	29.17 – 56.87	0.041
Methidathion	1.78 ±0.19	65.53	49.38 – 86.96	0.067
Profenofos	3.85 ±0.45	195.91	170.42 – 225.22	0.199
Fenitrothion	3.12 ±0.19	209.82	196.29 – 224.29	0.213
Ethoprop	2.04 ±0.30	291.34	241.39 – 351.62	0.296
Phoxim	1.08 ±0.01	306.52	304.62 – 308.43	0.311
Acephate	3.53 ±0.18	530.51	500.50 – 562.31	0.540
Triazophos	1.71 ±0.18	>1 000.00	–	>1.000
Pyrethroids				
Bifenthrin	0.43 ±0.01	3.97	3.89 – 4.05	0.004
Fenpropathrin	2.21 ±0.26	24.78	19.97 – 30.76	0.025
Beta-cypermethrin	1.77 ±0.31	57.84	38.45 – 87.02	0.059
Lambda-cyhalothrin	1.56 ±0.08	91.76	83.86 – 100.40	0.093
Carbamates				
Methomyl	1.85 ±0.13	14.12	12.63 – 15.79	0.014
Isoprocarb	0.63 ±0.07	403.65	230.70 – 706.25	0.411
Nereistoxins				
Cartap	2.41 ±0.16	131.20	120.78 – 142.53	0.133
Monosultap	3.00 ±0.11	>1 000.00	–	>1.000
Neonicotinoids				
Thiamethoxam	1.80 ±0.15	36.83	32.59 – 41.61	0.037
Imidacloprid	2.20 ±0.17	77.68	67.20 – 89.80	0.079
Acetamiprid	2.27 ±0.18	98.94	90.07 – 108.67	0.101
Phenylpyrazoles				
Fipronil	2.94 ±0.40	0.15	0.12 – 0.18	<0.001
Butene-fipronil	2.71 ±0.22	0.20	0.18 – 0.23	<0.001
Chlorfenapyr	0.60 ±0.03	192.16	144.33 – 255.85	0.195
Antibiotics				
Spinosad	1.53 ±0.14	176.96	144.05 – 217.37	0.180
Emamectin benzoate	2.09 ±0.33	435.85	300.22 – 632.75	0.443
Abamectin	2.24 ±0.10	982.97	937.23 – 1030.93	1.000
IGRs				
Hexaflumuron	2.13 ±0.19	>1 000.00	–	>1.000
Botanicals				
Azadirachtin	1.71 ±0.18	>1 000.00	–	>1.000
Matrine	1.71 ±0.18	>1 000.00	–	>1.000

Organophosphates, malathion, chlorpyrifos and acephate are recommended for control of tarnished plant bugs, and malathion is the most widely used organophosphates for control of *Lygus lineolaris* (Palisot de Beauvois). Carbamates methomyl exhibited significant efficacy against tarnished plant bugs (Scott and Gnodgrass, 2000; Zhu *et al.*, 2004). Malathion, methomyl, fenpropathrin and bifenthrin are registered for control of *Lygus hesperus* in strawberries (Udayagiri *et al.*, 2000). Likewise, endosulfan, an organochlorine insecticide, has relatively high acute contact toxicity to adults. There are few data available on the changes in conventional insecticides susceptibility in green plant bugs. But the extensive use of conventional insecticides against green plant bugs has provided an ideal environment for its evolution of resistance in Bt cotton. So the monitoring of insecticide resistance is very meaningful in chemical control in IPM.

Compared with many traditional insecticides, however, neonicotinoid insecticides thiamethoxam, acetamiprid, and imidacloprid had relatively low acute contact toxicity. But in field trials, where acetamiprid, imidacloprid and thiamethoxam were active against tarnished plant bugs, thiamethoxam was the most effective chemical of these neonicotinoids (Layton *et al.*, 2005). The causes of this difference may be that this class of insecticides mainly has oral toxicity due to its systemic nature. However, further quantitative analysis is needed to confirm this explanation. The phenylpyrazole insecticides with novel modes of action showed highest acute contact toxicity to green plant bugs. LC_{50} values for fipronil were 0.13 mg · L^{-1} by glass-vial (Table 1) and 0.15 mg · L^{-1} by topical application (Table 2), respectively. The novel insecticide fipronil disrupts normal nerve function by blocking the GABA-gated chloride channels (Cole *et al.*, 1993). It kills insects by contact and ingestion. Our results showed that fipronil had high contact toxicity to bugs. Butene-fipronil is a synthetic analogue of fipronil, therefore, its toxicity to adult green plant bugs was similar to that of fipronil in our study. Since the mid-1990s, fipronil has been recommended for control of tarnished plant bugs *Lygus lineolaris* in cotton in America, and remarkably enhanced the effectiveness of chemical control (Scott and Snodgrass, 2000). Among the 30 insecticides evaluated, antibiotics and botanical insecticides had no obvious acute contact toxicity to adult green plant bugs. IGR hexaflumuron functions as a chitin synthase inhibitor, this chemical showed no acute toxicity to adults for its mode of action. Further the influence of IGR hexaflumuron on physiology and behavior of green plant bugs needs to be investigated.

Two bioassay methods used are the prevalent methods for determining the toxicity of insecticides to mirids. Topical application which is widely applied to resistance test is recommended for the standard resistance test method for mirids by FAO, and the stage for determination is adult (Tang, 1993). Glass-vial bioassay was widely used to determine insecticide resistance levels in the tarnished plant bug populations (Snodgrass, 1996; Hollingsworth *et al.*, 1997; Snodgrass and Scott, 2000; Zhu *et al.*, 2004). For glass-vial bioassay, Hollingsworth *et al.* (1997) exposed 5 nymphs or adults per vial for 2 h and provided no food. With this method, results were obtained more rapidly, and the additional variable introduced with the green bean piece was avoided. The glass-vial used referred to the method described by Snodgrass (1996), which is the widely method for toxicity test of insecticides to mirids in laboratory. When compared the results obtained by two bioassay methods we used, there were no remarkable differences in the highest toxicities of all the test insecticides (Table 1, 2). The results showed that seven of eight most toxic compounds for the bugs among all the testing chemicals by glass-vial were same as topical application, and these seven insecticides were fipronil, butene-fipronil, chlorpyrifos, malathion, bifenthrin, methomyl and endosulfan. In addition, hexaflumuron (IGR), antibiotics and botanical insecticides showed the lowest toxicity to the bugs by the two methods. Therefore, they may prove effective and feasible for routine toxicity test to *L. lucorum*.

In summary, 30 insecticides were evaluated for their toxicity to an economically important pest in cotton, *L. lucorum*. The information provided here might be important for implementing scientific chemical control for green plant bugs IPM. However, the impact of insecticides on green plant bugs is complex, which requires a systematic study to determine short-term and long-term influence on the biology, physiology, and behavior of the populations.

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References

Abbott WS, 1925. A method of computing the effectiveness of an insecticide. *Journal of Economic Entomology*, 18: 265 – 267.

Cao CY, Wan CS, 1983. Management of Cotton Mirids. Shanghai Science and Technology Press, Shanghai. 5 – 9. [曹赤阳, 万长寿, 1983. 棉盲蝽的防治. 上海: 科学技术出版社. 5 – 9]

Cole LM, Nicholson RA, Casida JE, 1993. Action of pheylpyrazole insecticides at the GABA-gated chloride channel. *Pesticide Biochemistry and Physiology*, 46: 47 – 54.

Guo YY, 1997. Progress in the researches on migration regularity of cotton bollworm and relationships between the pest and its host plants. *Acta Entomologica Sinica*, 40 (Suppl.): 1 – 6. [郭予元, 1997. 棉铃虫迁飞规律及其与寄主植物的互作关系研究进展概况. 昆虫学报, 40(增刊): 1 – 6]

Hardee DD, Bryan WW, 1997. Influence of *Bacillus thuringiensis*-transgenic and nectariless cotton on insect populations with emphasis on the tarnished plant bug (Heteroptera: Miridae). *Journal of Economic Entomology*, 90: 663 – 668.

Hollingsworth RG, Steinkraus DC, Tugwell NP, 1997. Responses of Arkansas populations of tarnished plant bugs (Heteroptera: Miridae) to insecticides, and tolerance differences between nymphs and adults. *Journal of Economic Entomology*, 90: 21 – 26.

Layton MB, Long JL, Flint SG, Green LM, 2003. Control of tarnished plant bugs in Mississippi delta cotton. In: Proceedings Beltwide Cotton Conferences, National Cotton Council, Memphis, TN. 929 – 932.

Lu YH, Qiu F, Feng HQ, Li HB, Yang ZC, Wyckhuys KAG, Wu KM, 2007. Species composition and seasonal abundance of pestiferous plant bugs (Hemiptera: Miridae) on Bt cotton in China. *Crop Protection*, 27: 465 – 472.

Qu XF, Jiang YY, Zhang RJ, 2001. Current status and strategies of utilization of Bt cotton. *Plant Protection Technology and Extension*, 21(4): 37 – 39. [屈西峰, 姜玉英, 张跃进, 2001. 我国转基因抗虫棉应用现状和对策. 植保技术与推广, 21(4): 37 – 39]

SAS Institute Inc., 1997. SAS/STAT® Version 6.12. SAS Institute Inc., Cary, NC.

Scott WP, Snodgrass GL, 2000. A review of chemical control of the tarnished plant bug in cotton. *Southwestern Entomology*, 23

(Suppl.): 67 – 81.

Snodgrass GL, 1996. Glass-vial bioassay to estimate insecticide resistance in adult tarnished plant bugs (Heteroptera: Miridae). *Journal of Economic Entomology*, 89: 1 053 – 1 059.

Snodgrass GL, Scott WP, 2000. Seasonal changes in pyrethroid resistance in Tarnished plant bug (Heteroptera: Miridae) populations during a three-year period in the delta area of Arkansas, Louisiana, and Mississippi. *Journal of Economic Entomology*, 93: 441 – 446.

Tang ZH, 1993. Insecticides Resistance of Pest and Management. Agriculture Press, Beijing. 122. [唐振华,1993. 昆虫抗药性及其治理. 北京:农业出版社. 122]

Ting YC, 1965. Studies on the ecological characteristics of cotton plant bugs. Ⅲ. The pattern of spatial distribution of the plant bugs in cotton fields with analysis of its effective factors. *Acta Entomologica Sinica*, 14(3): 264 – 273. [丁岩钦, 1965. 棉盲蝽生态学特性的研究. Ⅲ. 棉盲蝽在棉田内的分布型及其影响因素的分析. 昆虫学报, 14(3): 264 – 273]

Udayagiri S, Norton AP, Welter SC, 2000. Integrating pesticide effects with inundative biological control: Interpretation of pesticide toxicity curves for *Anaphes iole* in strawberries. *Entomologia Experimentalis et Applicata*, 95: 87 – 95.

Wu KM, 2007. Environmental impacts and risk management strategies of Bt cotton commercialization in China. *Journal of Agricultural Biotechnology*, 15(1): 1 – 4. [吴孔明, 2007. 我国 Bt 棉花商业化的环境影响与风险管理策略. 农业生物技术学报, 15(1): 1 – 4]

Wu KM, Li W, Feng HQ, Guo YY, 2002. Seasonal abundance of the mirids, *Lygus lucorum* and *Adelphocoris* spp. (Hemiptera: Miridae) on Bt cotton in northern China. *Crop Protection*, 21: 997 – 1 002.

Zhao SH, 2000. Plant Chemical Protection. China Agriculture Press, Beijing. 250 – 253. [赵善欢, 2000. 植物化学保护. 北京: 中国农业出版社. 250 – 253]

Zhu HF, Meng XL, 1958. Studies on three species of cotton plant bugs, *Adelphocoris taeniophorus* Reuter, *A. lineolatus* (Goeze), and *Lygus lucorum* Meyer-Dür (Heteroptera: Miridae). *Acta Entomologica Sinica*, 8(2): 97 – 117. [朱弘复, 孟祥玲, 1958. 三种棉盲蝽的研究. 昆虫学报, 8(2): 97 – 117]

Zhu YC, Snodgrass GL, Chen MS, 2004. Enhanced esterase gene expression and activity in a malathion-resistant strain of the tarnished plant bug, *Lygus lineolaris*. *Insect Biochemistry and Molecular Biology*, 34: 1 175 – 1 186.

两种室内生物测定方法评价杀虫剂对绿盲蝽的相对毒力

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摘要: 随着 Bt 棉在我国的广泛种植, 绿盲蝽 *Lygocoris lucorum* Meyer-Dür 的危害日益加重。化学防治作为棉田盲蝽综合治理的重要策略, 仍是其主要的防治手段。本研究主要用闪烁管药膜法和点滴法两种测定方法评价了传统杀虫剂、新型杀虫剂等 30 种杀虫剂对绿盲蝽成虫的急性触杀毒力, 其中多种杀虫剂是首次使用两种生测方法同时进行毒力测定。结果表明:有机氯类、有机磷类、氨基甲酸酯类和拟除虫菊酯类等传统杀虫剂对绿盲蝽成虫具有较高的触杀活性。8 种对绿盲蝽成虫具有较高毒力的药剂, 其中 5 种为传统杀虫剂, 分别为马拉硫磷、毒死蜱、联苯菊酯、灭多威和硫丹。新型吡咯类杀虫剂对绿盲蝽表现出较高毒力, 以氟虫腈的毒力最高, 两种生测方法测定的 LC_{50} 分别为 0.13 $\mu g \cdot mL^{-1}$ 和 0.15 $\mu g \cdot mL^{-1}$。而昆虫生长调节剂、抗生素类及植物源杀虫剂对绿盲蝽成虫没有明显的触杀活性。

关键词: 绿盲蝽; 杀虫剂; 相对毒力; 触杀活性; 闪烁管药膜法; 点滴法

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